SCIENTIFIC PAPERS.

AN ECOLOGICAL COMPARISON OF SOME TYPICAL SWAMP AREAS.*

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In the preparation of the present paper the writer has undertaken the presentation of generally known facts regarding the swamp areas investigated, as a foundation for a future working out of the problems there suggested. It is intended to be a collection and grouping together of these data and so may be regarded as a necessary preliminary to such work as may be done hereafter in this field by the writer or by others.

The discussion of the various types of swamp which are here compared must necessarily consist of a description of the present topographical condition of each area, together with a summary of the principal plant forms which characterize it. Hence this paper may be considered as a brief presentation of the similarities and differences between certain swamp areas, expressed in terms of physiography and taxonomy, while the geological history and dynamics of each area are reserved until they can be studied in detail. Numerous interesting problems have presented themselves during the collection of these data and a few of them are mentioned in the paper. It is hoped that some of them may be taken up by others and the results of such investigation added to the too meager working library of the ecologist. The materials for this paper have been gathered during various ecological trips in the last three years, and

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the work has been done partly in connection with the Hull Biological Laboratory, University of Chicago, and partly in connection with the Shaw School of Botany, Saint Louis. The author herein acknowledges with gratitude the kindly assistance of his associates in both these laboratories, and, especially, the helpful suggestions of Professor John M. Coulter and Doctor Henry C. Cowles of the University of Chicago, and Professor William Trelease of the Shaw School of Botany. The maps and photographs were made by the author especially for this paper.

GENERAL VIEW OF THE AREAS STUDIED.

The areas investigated mostly lie along a line about 800 miles long running from near Mackinac Island, Michigan, southwesterly to the vicinity of Paragould, Arkansas, as indicated in the accompanying map. (Frontispiece.)

These studies comprise the following: —

1. A drained swamp along the Crooked River in the northern part of the lower Michigan peninsula.

2. An undrained tamarack-black spruce swamp surrounding a small lake on North Manitou Island, Michigan.

3. A slowly drained arbor-vitae swamp lying along the outlet into Lake Michigan of a larger lake on the same island.

4. The small, swampy lakes south of Chicago: Lake Calumet as a type.

5. Horse-shoe Lake in southwestern Illinois, an old ox-bow cut off from the Mississippi River.

6. A cypress-tupelo gum swamp along the Saint Francis River in northeastern Arkansas.

1. RIVER SWAMP ALONG CROOKED RIVER.

At the mouth of the Cheboygan River, near the northern extremity of the lower Michigan peninsula, a dam has been constructed which has considerably enlarged the areas of

a number of connecting lakes above it, and rendered sluggish the current in the small rivers uniting them. A large tract of country is now in a swampy condition on this account, many adjacent forest trees have been drowned out and it is probable that the flora has materially changed from its former condition. A precisely similar tract resulting from a like cause may be observed along Carp Lake in Leelanaw County, Michigan, where the water level has been raised about nine feet by a dam. (Plate 2.) The present flora in these two areas is remarkably similar. The tree zone or part farthest back from the Crooked River channel shows a large number of tamaracks (Larix Americana) probably indicating that the drainage is poor, the back water evidently not changing very rapidly. The arbor-vitae (Thuya occidentalis) and black spruce (Picea nigra) are almost equally prominent with the tamarack, while the white pine (Pinus Strobus), the Norway pine (P. resinosa), the balsam fir (Abies balsamea), the white ash (Fraxinus Americana) and the red maple (Acer rubrum) are the most important secondary trees.

The principal shrubs bordering the channels are the leather leaf (Cassandra calyculata), Potentilla fruticosa, Cornus circinata, C. stolonifera, Alnus incana and Salix glaucophylla. The most prominent herbs in this land margin are the Joe-pye weed and boneset (Eupatorium purpureum and E. perfoliatum), Lobelia cardinalis and L. syphilitica, Impatiens fulva, Polygonum amphibium and Osmunda regalis, the latter fern forming dense fringes overhanging the water's edge. In places where the channel is less defined, the low banks permit the spreading of the water and this land margin gives way to a water margin with a flora varying to meet the changed condition. Here are found great areas of Phragmites communis, Typha latifolia, Scirpus lacustris and Menyanthes trifoliata with Sagittaria variabilis and Iris versicolor in smaller patches. In the open water Nymphaea odorata, Nuphar advena, Pota-

mogeton natans, Vallisneria spiralis, Naias flexilis and species of Ceratophyllum and Myriophyllum are abundant.

The narrower portions of the water way, which extends almost to Petoskey, are kept pretty well cleared of aquatic vegetation by small steamers and lumber rafts. It is likely that the artificial maintenance of the water at near its present level will retard the natural process of filling this area and consequently alter the succession of floral types.

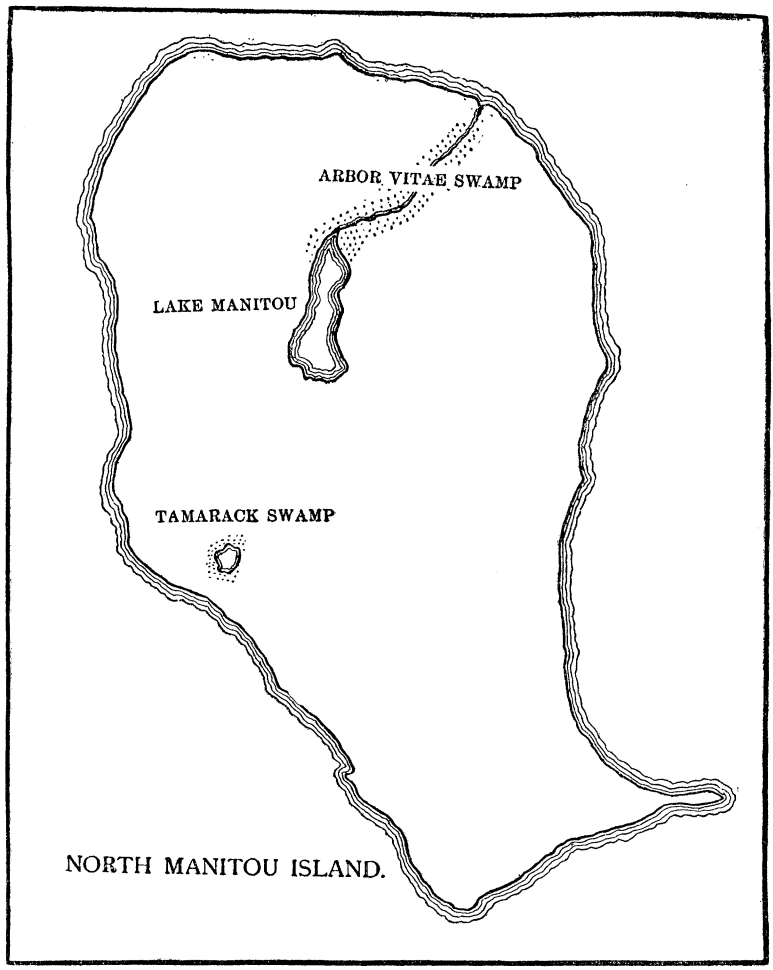
At the outlet of Walloon Lake near Petoskey, the channel is more definite, the stream is more rapid and the flora is more particularly that of a real land margin, the forms being generally such as are found in a very moist woods. The appended list shows the nature of the flora in the Walloon River area.

Acer rubrum.
Aralia nudicaulis.
Aralia racemosa.
Aspidium thelypteris.
Apocynum androsaemifolium.
Bidens connata.
Caltha palustris.
Campanula aparinoides.
Cicuta bulbifera
Conocephalus conicus.
Dalibarda repens.
Equisetum arvense.
Equisetum limosum.
Galium asprellum.
Galium triflorum.
Gaultheria procumbens.
Gentiana Andrewsii.
Hydrocotyle Americana.
Lathyrus palustris.
Leersia oryzoides.
Lonicera glauca.
Ludwigia palustris.
Lycopus Virginicus.
Mentha Canadensis.
Menyanthes trifoliata.
Myrica Gale.
Plantago major.
Rhus Toxicodendron.
Rosa Carolina.
Rubus triflorus.
Rumex verticillatus.
Salix lucida.
Solanum Dulcamara.
Solidago patula.
Thalictrum purpurascens.
Trientalis Americana.
Ulmus Americana.
Viola blanda.

2. UNDRAINED SWAMP.

The undrained tamarack and black spruce swamp is typically represented on the island of North Manitou. Here is a small decadent lake without an outlet which is gradually being filled up by the encroaching vegetation. (Plates 3, 4, and 5.)

The peat mosses which thrive so luxuriantly in poorly drained conditions are among the pioneer forms concerned in this process, while the cranberry (Vaccinium macrocar-



pon) quickly follows and soon forms a foothold for the leather leaf (Cassandra calyculata) and allied forms.

On the land margin the tamaracks and spruces are closely

crowding on the shrubs, and back of these, the hemlock-maple-beech forest is encroaching on the conifers. Whitford * has alluded to the succession of forms in this and similar areas. The flora here is notably peculiar, being decidedly different from any other area on the same island and almost exactly similar to that found in like localities elsewhere in the United States and in Europe. Some of the noticeable features of these swamps are the following: —

1. Large proportion of evergreens, both of the coniferous and broad-leaved types.

2. Pronounced xerophytic flora, *i. e.*, a flora adapted to resist transpiration, the leaves ericoid or pinoid, often vertical, covered with glaucous bloom, rarely pubescent.

3. Prevalence of carnivorous plants, Sarracenia purpurea and Drosera rotundifolia.

4. Abundance of forms bearing fleshy fruits, well adapted to seed dispersal by birds.

The much discussed question as to the prevalence of so-called xerophytic structures in these peat bogs is still an open one. Many suggestions have been made in the attempt to account for the apparent efforts of these swamp plants to protect themselves against loss of water by transpiration, while their environment seems to indicate that their water supply is unfailing and the adaptations for such protection unnecessary. It now seems probable that this "xerophytic" structure is due to some other cause than the mere effort to protect against water loss.

Kihlman † is of the opinion that the xerophytic structure belongs to northern forms which are exposed to strong

* Whitford, H. N., The Genetic Development of the Forests of Northern Michigan; A study in Physiographic Ecology. (Bot. Gaz. **31**: 313. 1901.)

† Kihlman, Pflanzenbiologische Studien aus Russisch-Lappland. (Acta Soc. pro Fauna et Flora Fennica, **6.** (1890).

winds and the coincident cooling of the earth. Johannsen * holds that these structural conditions are called forth by the reduced absorptive ability of the roots on account of an insufficient oxygen supply. Warming † adds to the above his belief that the xerophytic structure was required because the stomata had lost the power to close themselves. H. Nillson ‡ has arrived at the definite conclusion that the xerophytic structure stands in intimate connection with the paucity of nourishment in the soil.

The zonal distribution of plants is well illustrated in these tamarack swamps. Within the surrounding forest of maple, beech and hemlock, the real swamp area is found. The surface of the peaty soil is covered with Sphagnum and this zone is dominated by Larix Americana and Picea nigra.

Thuya occidentalis is next in importance and Acer rubrum, Betula lutea and Pyrus Americana are among the most noticeable of the remaining trees, though they are only occasionally found. Beginning in this zone and extending to the water's edge is an immense tangle of waist high shrubbery in which the leather leaf is most predominant, closely followed by Kalmia glauca, Vaccinium Canadense, Gaylussacia resinosa, Ilex verticillata, Nemopanthes fascicularis and Pyrus arbutifolia. In more open spots the marsh fern (Aspidium thelypteris) is exceedingly abundant while the Osmundas are equally so in the tree zone. The lake margin is very poorly defined, the shrub zone being more or less predominant in different localities. The most typical forms near the water margin are Potentilla palustris, Menyanthes trifoliata, Dulichium spathaceum, Lysimachia thyrsiflora, Cicuta bulbifera and Scutellaria galericulata, while the creeping snowberry, Chiogenes

* JOHANNSEN, Plante fysioligi. 324.

† WARMING, Plantesamfund. 150.

‡ NILLSON, H., Einiges uber die Biologie der schwedischen Sumpfpflanzen. (Bot. Cent. 76:9).

serpyllifolia, is found overrunning all the areas described above. Gaultheria procumbens, Sarracenia purpurea and Drosera rotundifolia are likewise common but not confined to any particular zone.

Coming into the open water, Polygonum Hartwrightii, Phragmites communis, Typha latifolia and Nuphar advena complete the list of common and typical forms.

In a peat bog in the vicinity of Mount Katahdin, Maine (Plate 6), the filling up of the depression had progressed farther and there was little open water remaining. Although this area is 2,600 feet above tide water, there is found a considerable similarity between the species represented there and those in the northern Michigan swamp. Larix Americana is very scarce in the Maine region, though the lumbermen say that a number of years ago it was plentiful but was killed off by "borers." In any case the dominant tree now found about this swamp is the black spruce, Picea nigra.

These trees are very small upon the east side, larger on the north, where are found a number of trees of Thuya occidentalis also, and largest upon the west side where Pyrus Americana is associated with the spruce. It is practically the only tree on the south side.

Among the shrubs characterizing the Northern Michigan area, there were found here Cassandra calyculata, Nemopanthes fascicularis, Kalmia glauca and Pyrus arbutifolia. Vaccinium Canadense is found in the neighboring thickets; and in the bog itself are found V. Oxycoccus, V. uliginosum and V. Vitis-Idaea.

The strictly water forms, Potentilla palustris, Menyanthes trifoliata, Polygonum Hartwrightii, Phragmites communis and Typha latifolia were not found in the Maine swamp: as has been already stated there is little open water left. In the wettest places species of Sphagnum, Scheuchzeria palustris, Drosera rotundifolia and Sarracenia purpurea are the typical plants. Osmunda cinnamomea is a character-

istic plant in the shrub zone. The character plants found in the Katahdin region and not in Michigan are Carex miliaris, Eriophorum gracile, Ledum latifolium, Viburnum cassinoides, Smilacina trifolia Empetrum nigrum.

In a small sphagnum bog on Long Island, New York, there was observed a still later condition in which the water was practically all gone, except in small depressions where the Sphagnum is growing luxuriantly. Associated with the Sphagnum or growing in a habitat slightly elevated above it, are Aspidium thelypteris, Onoclea sensibilis, Osmunda cinnamomea, Impatiens fulva, Elodes campanulata, Hydrocotyle Americana, Mimulus ringens, Rhexia Virginica, Eupatorium perfoliatum, E. purpureum, Asclepias incarnata, Rubus hispidus and Alnus serrulata. It will be readily observed that this association suggests a brookside flora rather than that of a sphagnum swamp, and it is probably due to the fact that as the vegetation increased, areas were elevated somewhat and the water was gradually drawn off into small channels, thus giving the area a little better drainage.

The Sphagnum still clings to those depressions where the drainage is slow.

Sarracenia purpurea and Drosera rotundifolia have been reported from this locality, but they could not be found at the time these observations were made. If these forms are disappearing, it would tend to corroborate the above hypothesis. The marginal flora is becoming heath-like, the most characteristic forms being Alnus serrulata, Myrica cerifera, Pinus Strobus saplings, Juniperus Virginiana, Vaccinium Canadense, Chrysanthemum Leucanthemum, Anaphalis margaritacea, Epigaea repens, Polytrichum commune and Cladonia rangiferina.

3. SLOWLY DRAINED SWAMP.

A much larger lake than the one described above is found on the same island; its banks are well defined and rarely

marshy with the exception of the northeastern end, where the lower level of the ground has permitted an outlet into Lake Michigan. (Plate 7.) As no large volume of water overflows, it has not succeeded in cutting out a well-defined channel. The rapidly growing vegetation has assisted in the partial damming of this small stream, so that it has gradually spread out until quite a large area is now occupied by its meanderings. The current, although exceedingly sluggish, has a general onward movement, slowly changing the water about the roots of the vegetation. Probably from this cause or one related to it, the vegetation is strikingly different from that in the last described area. The largest tree in this swamp is the white pine (Pinus Strobus), but the dominant one is the arbor-vitae (Thuya occidentalis), here growing to great size, fifty feet in height and twenty inches in diameter. A great many dead and dying trees are found, but whether they have lived out their natural existence or died from lack of sufficient nourishment, it is impossible to say. The fall of these dead trees has been attended by the uplifting of great masses of earth and organic debris which have united to form large hummocks throughout the swamp and the existence of these hummocks has determined the vegetation to a great degree. This great tract of trees and undergrowth amid a mass of fallen logs and brush forms a dense jungle of vegetation which is almost impenetrable.

Next in importance to the arbor-vitae comes the white ash (Fraxinus Americana), the only deciduous tree observed except an occasional yellow birch (Betula lutea) encroaching from the marginal forests. Abies balsamea is frequently found here. In a rather similar area studied on Beaver Island, Mich., the tamarack is quite abundant as is also the paper birch (Betula papyrifera). The principal shrubs occurring near the margin or upon the hummocks are second growth arbor-vitae, Acer Pennsylvanicum and A. spicatum. The yew (Taxus Canadensis), which

is a typical dense shade shrub, is found abundantly. On Beaver Island there are added Salix rostrata, Populus balsamifera and Ledum latifolium. Among the herbs, the shade loving ferns, Osmunda regalis, Botrychium Virginianum and Cystopteris bulbifera are prominent, while in the more open spots where there is abundance of water, Scutellaria lateriflora, Lycopus Virginicus, Impatiens pallida, and Epilobium coloratum are most characteristic. In the Beaver Island area the swamp is much drier and soil herbs are more typical.

Among these Symplocarpus foetidus is very common. The most abundant low herbs in both areas are Linnaea borealis, Dalibarda repens, Viola blanda, Coptis trifolia, Chiogenes serpyllifolia, Clintonia borealis and Galium triflorum. Marchantia and Conocephalus grow abundantly in the wetter places while the mosses luxuriate upon the logs. Hypnum crista-castrensis, Climacium dendroides, Thuidium delicatulum, Dicranum scoparium, Mnium sylvaticum and Sphagnum squarrosum are among the dominant forms. Later stages in the history of the arbor-vitae swamp may be observed in the region about Little Traverse Bay on the main land.

Along the outlet of Roaring Brook, the conditions are mesophytic at present, though the most characteristic plants are still the same as those in the typical area just described. Associated with them, however, are the rapidly encroaching plants one might expect to find in such a mesophytic area, and here may be seen the probable destiny of the arbor-vitae swamp. Notable among these plants are Aralia nudicaulis, Trientalis Americana, Lycopodium lucidulum, Cornus Canadensis, Maianthemum Canadense and Streptopus roseus.

4. THE PRAIRIE SWAMPS ABOUT CHICAGO.

Lake Calumet is one of a series of small lakes which occupy the lower depressions of old Lake Chicago. Other

lakes of this series lie between Lakes Calumet and Michigan, representing various stages in the history of the pond from the open water to the typical prairie or forest. Lake Calumet is three and one-half by one and one-half miles in extent and its drainage is somewhat peculiar. In the southeast corner begins a stream, the first 200 yards of which forms the main stem of a Y. One of the arms of the Y stretches southward forming the Calumet River which, with its tributaries, drains a large section of the surrounding country. The other arm turns north and, after a somewhat tortuous course of six miles, flows into Lake Michigan. At some periods of the year, the current is flowing into Lake Calumet, at other periods it is flowing out. Conditions of rain fall, evaporation and other factors regulate this flow. Lake Calumet is, therefore, simply a bayou of the Calumet River and is subject to an average variation of twenty-two inches in level during the year. The southern end of the lake is thus afforded a considerable amount of drainage and consequent change of water. On the same account the northern end of the lake is subject to a much smaller degree of drainage, and even this small amount is much retarded by the great abundance of vegetation in this part. It is interesting to note in this connection that in the northern end are found such forms as Riccia and Ricciocarpus which are known to thrive well where the drainage is poor. A comparative study of the forms in the northern and southern portions of the lake could well be made with a view to discovering what influence the question of drainage exerted upon their determination. The western shores as well as the northern are exceedingly marshy.

Dense formations of Scirpus lacustris extend for nearly one-half a mile into the lake, scattered patches being found far out from the general mass of vegetation.

Occasional clumps of bulrushes are forming potential islands along the eastern shore and in the northeastern

part an island of considerable dimensions has been formed, composed principally of the remains of former vegetation and now supporting quite a variety of plants. As one comes south along the eastern shore, open stretches of water are found where the usual marginal growth of rushes has been interrupted. This may be related to depth of water, nature of substratum, exposure or manner of propagation. The latter thought suggests the question whether propagation here takes place by rhizomes extending in the soil under the water, or whether the seeds float a while, then sink and germinate. Associated with these open areas, there is found an erosion of the shore until a bluff is formed two or three feet high. This is the natural result of the action of the waves raised by the prevailing west winds upon a shore where there is no protecting fringe of vegetation. Extensive masses of the tubers and rhizomes of Scirpus fluviatilis help to bind together the soil of these exposed bluffs, the slow decay of the wiry rhizomes retarding the erosion to a considerable degree. An interesting point for investigation would be the change of condition which is now causing the erosion of an area which at one time was permitted to be deposited. Many of these old root remains are two feet beneath the surface and must have been in position a long time. The area immediately east of these little bluffs is level and raised only a few feet above the lake. It is occupied by gardens or small farms and the alluvial soil is cultivated to within a few feet of the water, a fringe of tall weeds occupying the edge of the bluff. The same weeds occupy a position corresponding to a similar depth of soil where there is no bluff, but where the protecting vegetation has permitted a marshy soil formation to the lakeward side of the weeds. The dominant forms are Ambrosia trifida, Amarantus retroflexus, Chenopodium album and Melilotus alba. In the open water of the lake there is a great abundance of strictly aquatic vegetation. Among the most important

may be mentioned the Potamogetons, Heteranthera graminea, Pontederia cordata, Brasenia peltata, Elodea Canadensis, Myriophyllum and Ceratophyllum. Cowles* has listed the character plants of this area and discussed its dynamics to some extent. An exhaustive study of the history of this and other areas in the pond-swamp-prairie series would form a valuable addition to ecological literature.

5. HORSE-SHOE LAKE, AN OLD "OX-BOW" OF THE MISSISSIPPI.

In the lowlands of the Mississippi opposite Saint Louis there are many of these depressions which have once been a part of the river bed, but are now cut off by the shifting of the channel. One may find them in every stage of advancement, from the open lake through the marsh to the solid "bottom land." As has been said of the pond-swamp-prairie series, so it may be stated of this region, that a thorough investigation of the conditions at work in filling up these lakes and swamps, and the succession of forms concerned in the process would comprise a welcome contribution to this department of science.

On the northern shore Nelumbo lutea is the prevailing type plant farthest from the shore. An occasional Nymphaea odorata may be observed. (Plate 8.)

Scirpus maritimus is the prominent water margin plant, extending up the marshy shore 40 or 50 feet. This gives the tone to the landscape at this point, but an important, though inconspicuous, plant which borders it lakeward is Jussiaea repens. Associated with the Scirpus maritimus and partially concealed by it is a species of Eleocharis which becomes very vigorous and abundant in places where the taller bulrush is more sparse.

In other places the Eleocharis has been forced more to

* Cowles, H. C. The Plant Societies of Chicago and vicinity. (Bulletin of the Geographic Society of Chicago. 2:41. 1901.)

the water's edge by the Scirpus. Scirpus lacustris is also present here, but remains secondary in importance to S. maritimus. Sagittaria variabilis follows along the shore in patches. Bidens frondosa begins in this zone but culminates on the shore side. Diminutive forms, Wolffia, Lemna and Spirodela, are found abundantly in this zone. The second zone varies greatly in width and the tension line between it and the first is very irregular.

The Carices are the most abundant forms, but not so conspicuous as some larger plants which are equally common with each other. This association consists of Polygonum Muhlenbergii, Boehmeria cylindrica, Apocynum androsaemifolium, Hibiscus militaris, Amorpha fruticosa and Bidens frondosa. Pilea pumila is very abundant but not conspicuous. Bordering this zone, there is a slight rise of six inches or more which is sufficient to introduce a shrub or tree margin, and along this border line Amsonia Tabernaemontana, Cephalanthus occidentalis and Salix longifolia are prominent. (Plate 9.) In the shrub zone one notes a few climbing forms, Polygonum scandens, Apios tuberosa and Strophostyles palustris. Eupatorium coelestinum is most common, E. altissimum and Erigeron annuus are secondary, while Salix amygdaloides and Betula lutea are the most characteristic shrubs. This zone gradually merges into the real tree zone which occupies the old river shore. Immense sycamores (Platanus occidentalis), swamp maples (Acer rubrum) and cottonwoods (Populus monilifera) are the typical trees. A dense undergrowth of shrubs is found here, the most noticeable of which are Betula lutea, Salix amygdaloides, Forestiera acuminata, Ulmus fulva, Fraxinus Americana, Crataegus viridis, Cornus asperifolia and Gleditsia triacanthos. Sicyos angulata, Vitis cinerea, V. riparia and Tecoma radicans are the prominent lianas. Boehmeria cylindrica, Astragalus Canadensis and Oenothera biennis are common and in small clearings Ambrosia trifida and A. artemisiaefolia have been introduced.

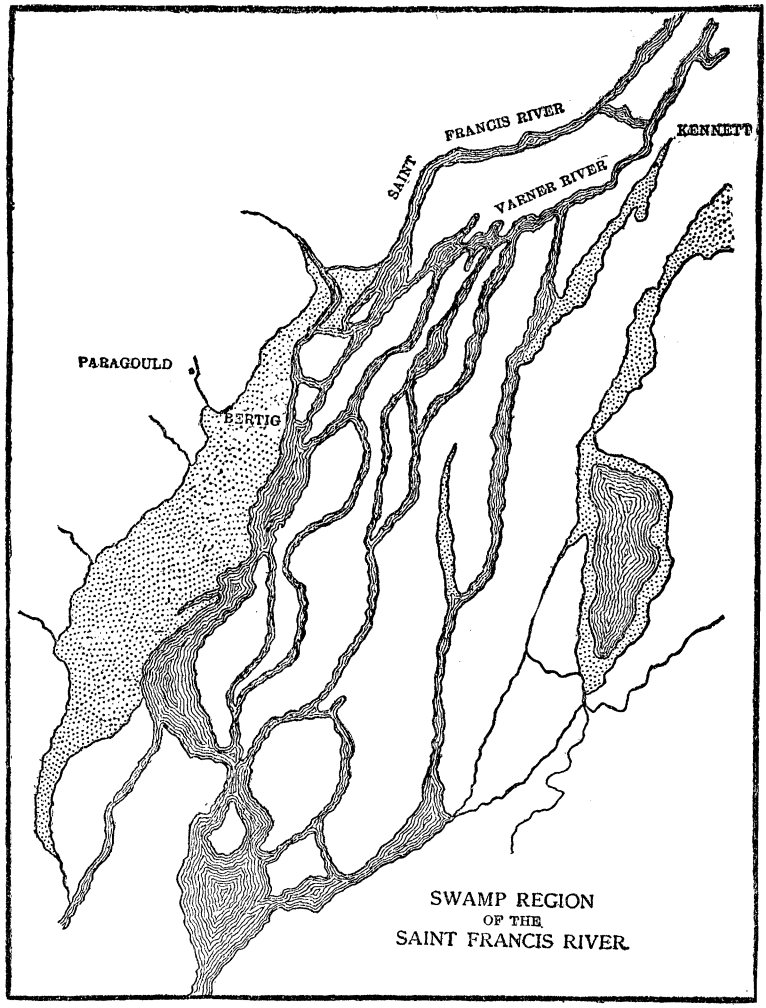
Farther east a small stream enters the lake and along its quiet shore Jussiaea repens forms a conspicuous border. (Plate 9.) Scirpus maritimus is wanting and Polygonum Muhlenbergii and Sium cicutaefolium crowd each other for the next place and then quickly give way to a shrubby thicket of Salix nigra, S. amygdaloides and S. longifolia, which, in turn, are almost entirely succeeded by Forestiera acuminata, a form which seems so well adapted to this habitat, that other forms scarcely exist in the almost impenetrable thicket it makes beyond the willows. There is no ground vegetation whatever and only an occasional willow. An interesting adaptation is shown by the Forestiera which accounts in part for this dense thicket growth. Where the long, drooping branches touch the wet soil, roots are quickly put out and in a short time young and independent trees have originated. (Plate 10.) Somewhat north of this thicket an axe clearing has been made, and here the same willows are beginning to come in.

Typha latifolia is the commonest plant here, Bidens frondosa nearly equaling it. Sagittaria variabilis occupies the moister places, Penthorum sedoides is also frequent and seedlings of Acer dasycarpum are abundant. Bounding the Forestiera thicket and the clearing one finds large trees of Fraxinus Americana and Acer dasycarpum farther back.

6 A CYPRESS-TUPELO GUM SWAMP ALONG THE ST. FRANCIS RIVER.

A tract of land lying in Dunklin County, Missouri, and in Greene County, Arkansas, furnishes an excellent area for the study of a semi-southern river swamp. Through this territory runs the Saint Francis River, and it, together with its tributaries, covers wide stretches of the lowlands with a varying depth of water. At some seasons one may pass dry-shod over miles of woodland, which at other seasons is covered with water to a depth of two feet or more. It is this variability in amount of water which ren-

ders the conditions of these swamp lands peculiar, and makes their study particularly interesting. In the vicinity of Bertig, Arkansas, there is an average fluctuation of



about twenty-four inches during the year, though this has been observed to reach as much as forty-four inches. In the spring when the water was some fifteen inches below

its maximum mark, observations were begun. In open spaces where the water is sufficiently quiet, the Polygonum densiflorum seems to be the first in order of succession of those plants which obtain a foothold in the soil and lift themselves out of the water. A large proportion of the river bottom is covered with Myriophyllum, Ceratophyllum, Potamogeton and Cabomba, and this filling up of the channel and consequent slowing down of the current renders it possible for such amphibious plants as Polygonum and Zizaniopsis miliacea, which succeeds it very closely, to secure a foothold. (Plates 11, 12, and 13.)

In a similar locality on the Varner River, near Kennett, Missouri, the Polygonum was found and associated with it Typha latifolia and Peltandra undulata. In many quiet places clear of larger growth, the water is literally covered with Azolla Caroliniana, with a considerable amount of Lemna minor and occasional plants of Ricciocarpus natans. Going shoreward the Polygonum still persists in abundance, Peltandra increases, Saururus cernuus appears and is almost equally represented. Sium cicutaefolium appears in this zone also. A willow undergrowth marks the beginning of what may be considered the next zone, and, quickly following the willows, one notes the Cephalanthus occidentalis which soon becomes conspicuous. Where the underbrush is interrupted, immense areas of Nelumbo are found interspersed with Nuphar advena, the great leaves crowded together in dense masses. In this zone closely following the button bush and willows the tupelo gum (Nyssa uniflora) and the bald cypress (Taxodium distichum) first make their appearance, and the characteristics of these two trees and their relations to the swamp lands are worthy of a thorough investigation.

Nyssa uniflora.

In very early spring when the areas in which the tupelos are growing are flooded, one may find the inch long

fruits floating everywhere, and shortly after the water has subsided, the ground is thickly covered with little seedlings whose continuance depends on their ability to keep their heads above water when it rises. In the latter part of October, they were observed to be about a foot in height and growing vigorously and rapidly. The soil at that time was comparatively dry. Every gradation in size may be observed in the tupelos of these river swamps. In one region they were mere shrubs, not exceeding twenty feet in height. In certain other areas where the Nyssa is entirely dominant, young trees from thirty to fifty feet in height are standing straight and close together, the crown of leaves high up and very few branches below. (Plate 1.) Near the water line occurs the characteristic bulge in the trunk which becomes so pronounced in the older tree. For a considerable space above and below this water line, the trunks in April were covered with a species of Porella which seems to thrive luxuriantly in this habitat. As the tupelos in the swamp grow older, one finds the lower portion of the trunk continuing to increase in diameter and soon forming a dome-shaped base quite different in appearance from the cone-shaped cypress base in a similar habitat. (Plate 18.) This process is accompanied by the dying away of the tops and the decay of all central tissue until the tree consists of a hollow dome with the shaft above usually broken off thirty or forty feet above the ground, a few scattering limbs bearing what scanty foliage remains.

The tissue of the tree is often torn partially from the roots as the base enlarges, and infoldings occur at the ruptured points which become covered with bark. Similar crevices or splits above the roots often appear as the trunk increases in size, and the bark soon covers the edges and extends some distance within the inner surface. At the time the photograph of the large tupelo shown in the upper figure of Plate 19 was made, there was 22 inches of

water upon the ground and the diameter of the base at the water's edge was twelve feet. The same tree was observed in the fall when the ground was dry, and its circumference where the roots entered the ground was 45 feet. The tupelo in the lower figure of Plate 19, measured 55 feet in circumference where the roots entered the ground, and its height was only 45 feet, a considerable portion of the upper part having been broken off. What the advantage accruing to the tupelo from this enlarged base may be is a matter of much speculation; none of the suggestions so far offered have seemed adequate to the writer. It is certain at least, that no physiological cause has yet been assigned. Where the water supply is scanty, the base is only slightly enlarged, and under ordinary conditions the trunk is normal. The Cypress thrives well in similar areas in this region, but in the Kennett district, nearly all the trees are tupelos. The cypresses are old, dying or dead, and few younger ones are coming on to replace them. In such places one notes particularly the great abundance of epiphytic vegetation. Every dying tree, stump, cypress knee, decaying log or floating limb is literally hidden by a rank growth of grasses, sedges, Rosa Carolina, Itea Virginica and many other forms. (Plate 20.) As the tupelo base enlarges, it affords a favorable foothold for the epiphytic fern, Polypodium incanum, which often completely covers it. This fern possesses the characteristic of shriveling and rolling up its coriaceous leaves during dry weather, and quickly spreading them out again, and becoming bright green in rainy weather.

Taxodium distichum.

The habitat of the cypress is quite similar to that of the tupelo; though it seems probable that the cypress is not the equal of the tupelo in the struggle for the occupancy of this territory. The seedlings and young growing trees of the latter are much more numerous than those of the

former tree. The groves of young cypress are not so unmixed in the Bertig region as those of the tupelo. It can be seen from the photographs that a considerable amount of undergrowth accompanies the cypress; it consists of young tupelos, Cephalanthus occidentalis, Mikania scandens, etc.* (Plate 15.)

The young trees early acquire the conical butt and the roots are soon lifted above the surface of the ground or water, forming the conspicuous "knees" of the cypress forest. (Plates 16, 17 and 18.) It is very noticeable in the Bertig region that the young and middle aged trees have the conical base, while the oldest trees have not, although in the latter case the knees are enormously developed. This is not true of the tupelo, as the base continues to increase in size during the life of the tree. The enlargement of the base of the cypress does not seem to be attended by decay and death, as in the tupelo, but this enlargement, as well as the development of the knees, accompanies the growth in swamps. When growing in dry soil, neither phenomenon occurs. If, as currently reported, there has been a general subsidence of these so-called "sunken lands," it may account for the fact that the older cypresses have not the enlarged base, that is, they may have occupied relatively higher and drier ground until they were well grown and not subjected to the conditions which cause the enlargement of base. After subsidence the newer roots might have developed the knees which are now present. When the usual waters have subsided, the writer has observed these upgrowing roots to have attained a hight of eight feet above the surface of the ground. The general impression exists that these are "breathing roots" and serve the purpose of conveying oxygen to the parts submerged in underlying mud.

* However, near the confluence of the Varner and St. Francis Rivers, fifteen miles above Bertig, there are large groves of cypress covering many square miles in which very few other trees are found.

The comparatively smooth bark of the cypress does not furnish so good a foothold for the Porella, Polypodium and other epiphytes as does that of the tupelo, hence there is little epiphytic vegetation upon the living trees.

The changes one notes in ascending the Saint Francis River from Bertig to Kennett, some thirty-five miles, are not so much in the forms present as in the distribution of those forms. There is a gradual narrowing of the area occupied by the Polygonum-Zizaniopsis association and an encroachment upon it of the Taxodium-Nyssa association. While there is a great deal of the tupelo, in pure or mixed groves, distributed all the way up the river to Kennett, it is noticeable that the cypress increases decidedly. The nature of the woods marginal to the Taxodium-Nyssa association is described below.

Wherever the land appears above the water, in small or in large islands, the forms mentioned usually appear upon it. From experiments made with the cypress as illustrated in Plate 16, it is not necessary for it to be surrounded with water in order to grow vigorously. It seems reasonable to suppose that the conditions upon these islands are suitable for the growth of the cypress, and that it would be found there, were it not for the encroachment upon it of the more vigorous broad-leaved forms. As the latter are evidently stronger in the struggle for occupancy of an area possessing the conditions they require, the cypresses are driven off the land where the broad-leaved trees can live, into the water where they cannot follow. This is well illustrated on all the marginal uplands and islands, for example, at Bear Island where the land is occupied with oaks, sweet gum, etc., while the cypress crowds up to them on all sides, the amount of water marking the tension line between the two types.

In open areas in which the soil of the cypress forest is never covered with a great depth of water, but is dry a

good portion of the year, immense thickets of Planera aquatica are formed.

Sometimes these shrubs are small, forming an almost impenetrable thicket, in other places the trees are larger and much farther apart. The downy red maple, Acer Drummondii, is a notable form as one goes from the swamp proper to higher ground. An interesting succession of the varieties of the ash may be observed in the progress from swamp to mesophytic conditions. Common in the swamp is found Fraxinus Americana profunda; on somewhat higher ground, Fraxinus viridis; in mesophytic surroundings, Fraxinus Americana. The largest of the very abundant trees in these marginal forests is the sweet gum (Liquidambar styraciflua), and associated with it, white and red oaks, immense sassafras trees, Quercus Michauxii, Platanus occidentalis, Gymnocladus Canadensis, Celtis Mississippiensis and Nyssa sylvatica. (Plate 20.) Among the shrubs are found Cercis Canadensis, Lindera Benzoin, Cornus paniculata, Asimina triloba, Ulmus alata, Morus rubra, Euonymus Americanus sarmentosus and Aralia spinosa.

Among lianas are Tecoma radicans, Rhus toxicodendron, Bignonia capreolata and Ampelopsis quinquefolia. An interesting southern form found abundantly in these swamp lands is the cork tree (Leitneria Floridana).

Inasmuch as we find here a meeting-point of the southern forms which have followed up the sluggish tributaries of the Mississippi, and the northern forms which are migrating southward, the farther study of this area is likely to prove intensely interesting. The difficulties attending the separation of these floras ecologically and assigning each part its position, on account of climatic, topographic or moisture conditions, are many, and such a discussion will find no place in this paper, which, as stated in the outset, is intended to be a collection of reliable data concerning these swamp areas.

SWAMPS OF THE BERMUDAS.

The writer has recently had the opportunity of visiting an undrained peat swamp and also a mangrove swamp on the Bermuda Islands and a brief note regarding them may be of interest.

The Devonshire marsh is a large area which gives evidence that it was once a pond, or, at least, contained much more water than it does at present. It is only a marsh land now with a few pools in the depressions. Two species of Sphagnum were found in these pools, also the mermaid weed, (Proserpinaca palustris) and Lemna minor. The water hyacinth and the cat-tail were abundantly represented in the wettest places, while rooted in the mud were Hydrocotyle Asiatica, Herpestis Moniera, Mentha viridis and Dichromena leuocephala. An immense West Indian fern, Acrostichum aureum, here reaches a hight of seven or eight feet. As the ground becomes a little drier, Osmunda regalis and O. cinnamomea become abundant, the latter especially so. In still drier, peaty soil, Pteris aquilina caudata is growing vigorously and becomes much taller than one's head. The Bermuda cedar (Juniperus Bermudiana), the Palmetto (Sabal Blackburniana) and the dog-bush (Baccharis heterophylla), are the most prominent woody forms. (Plates 21 and 22.) In the driest and most exposed places, the ground is covered with Cladonia and Leucobryum. The resemblance to our own drier Sphagnum swamps is apparent. Sphagnum, royal and cinnamon ferns, cat-tails, brake-fern, reindeer lichen and Leucobryum are all characteristic. The tamaracks or spruces are replaced by the cedar, our local shrubs by those of Bermuda.

A second type is shown by the mangrove swamp at Hungry Bay. (Plates 23 and 24.) This swamp is connected with the ocean and there is a tidal fluctuation of two or three feet. The lower depressions over an area of

several acres are crowded with a dense growth of mangroves fifteen or twenty feet in height.

The general characteristics of the mangrove, Rhizophora Mangle, may be briefly stated.

From the main axis, numerous curving prop-roots are sent down into the mud, giving the tree the appearance of an inverted candelabrum. (Plate 22.)

As these prop-roots branch repeatedly, they soon make an impenetrable tangle of the mangrove swamp. In addition to this, the horizontal limbs send down perpendicular aerial roots which usually branch before entering the water or mud.

The diameter of these roots is approximately the same near the tip as at the point of insertion. The seeds send out pointed radicles while on the tree. When mature they drop to the ground and the pointed end sticks into the soft mud, holding the body erect. It continues growing, the lower end soon becomes rooted in the earth, while the upper end develops a pair of leaves. The mud under the trees is usually covered with these vigorously growing seedlings.

Associated with the true mangrove, there is usually found the false mangrove, Avicennia nitida, which affects a similar habitat. So far as the writer has observed, the latter never sends out aerial roots, though an interesting phenomenon was noticed upon a group of old trees growing in the edge of Walsingham Bay. From the main axis and large branches near the first fork, there were developed numerous short processes, similar to aerial roots except that they were only a few inches long and in clusters. (Plate 24.)

Avicennia nitida possesses one characteristic not shared with Rhizophora so far as observed, viz., it sends up from the roots perpendicular processes to the hight of several inches. These are crowded about the area subtended by

the roots and rise to the surface of the water or slightly above. They are usually less than an inch in diameter and do not taper, so that, in appearance, they resemble somewhat the aerial roots of Rhizophora.

It may be that their function is the same as that of the cypress knees. Besides the seedlings of the mangroves, there may be found along the edge of the water, Salicornia fruticosa, Statice Lefroyi, Sesuvium portulacastrum and Heliotropium curassavicum. Beyond tidewater Conocarpus erectus, the sea mulberry, is abundant. Coccoloba uvifera, the sea-side grape, a large tree with broad glossy leaves and grape-like bunches of fruit, is also a common marginal form. Then appear Borrichia arborescens, Solidago sempervirens, Lantana odorata and Lantana Camara, forming the so-called Bermuda sage-brush. The cedar follows and the vegetation rapidly becomes that found on all the hillsides.

The accompanying table will serve to give a graphic view of the distribution of the characteristic plant forms mentioned in the body of the paper.

Comparative Table of Species.	Crooked River.	Walloon River.	Sphagnum swamp N. Manitou.	Sphagnum swamp Mt. Katahdin.	Sphagnum swamp Long Island.	Arbor-vitæ swa'p N. Manitou.	Arbor-vitæ swa'p Roaring Brook.	Lake Calumet.	Horse-shoo Lake	St. Francis River.
Abies balsamea	—					—				
Acer dasycarpum									—	
Acer Pennsylvanicum						—				
Acer rubrum	—		—						—	
Acer Drummondii										—
Acer spicatum						—				
Alnus incana	—									
Alnus serrulata					—					
Amarantus retroflexus								—		
Ambrosia artemisiafolia									—	
Ambrosia trifida								—	—	
Amorpha fruticosa									—	
Ampelopsis quinquefolia										—
Amsonia Tabernaemontana									—	
Aplos tuberosa									—	
Apocynum androsaemifolium		—							—	
Aralia nudicaulis		—					—			
Aralia racemosa		—								
Aralia spinosa										—
Asclepias incarnata					—					
Asimina triloba										—
Aspidium thelypteris		—	—		—					
Astragalus Canadensis									—	
Azolla Caroliniana										—
Betula lutea			—			—			—	
Betula papyrifera						—				
Bidens chrysanthemoides										—
Bidens connata		—								
Bidens frondosa									—	
Bignonia Capreolata										—
Boehmeria cylindrica									—	
Botrychium ternatum										—
Botrychium Virginianam							—			
Brasenia peltata								—		
Cabomba Caroliniana										—
Caltha palustris		—								
Campanula aparinoides		—								
Carex miliaris				—						
Cassandra calyculata	—		—	—						
Celtis Mississippiensis										—
Cephalanthus occidentalis									—	
Ceratophyllum demersum	—								—	—
Cercis Canadensis									—	
Chenopodium album								—		
Chiogenes serpyllifolia			—			—				
Climacium dendroides						—				

Comparative Table of Species.	Crooked River.	Walloon River.	Sphagnum swamp N. Manitou.	Sphagnum swamp Mt. Katahdin.	Sphagnum swamp Long Island.	Arbor-vitae swa'p N. Manitou.	Arbor-vitae swa'p Roaring Brook.	Lake Calumet.	Horse-shoe Lake.	St. Francis River.
Cicuta bulbifera		—	—							
Clintonia borealis						—				
Conocephalus conicus		—				—				
Coptis trifolia						—				
Cornus asperifolia									—	
Cornus Canadensis							—			
Cornus circinata	—									
Cornus paniculata										—
Cornus stolonifera	—									
Crataegus viridis									—	
Cystopteris bulbifera						—				
Dalibarda repens		—				—				
Dicranum scoparium						—				
Drosera rotundifolia			—	—						
Dulichium spathaceum			—							
Eleocharis									—	
Elodea canadensis								—		
Empetrum nigrum				—						
Epilobium coloratum						—				
Equisetum arvense		—								
Equisetum limosum		—								
Erigeron annuus									—	
Eriophorum gracile				—						
Euonymus Americanus sarmentosus										—
Eupatorium altissimum								—		
Eupatorium coelestinum								—		
Eupatorium perfoliatum	—				—					
Eupatorium purpureum	—				—					
Forestiera acuminata									—	—
Fraxinus Americana	—					—			—	—
Fraxinus Americana profunda										—
Fraxinus viridis										—
Galium asprellum		—								
Galium triflorum		—				—				
Gaultheria procumbens		—	—		—					
Gaylussacia resinosa			—		—					
Gleditsia triacanthos									—	
Gentiana Andrewsii										—
Gymnocladus Canadensis		—								
Heteranthera graminea								—		
Hibiscus militaris									—	
Hydrocotyle Americana		—			—					
Hypnum crista-castrensis						—				
Ilex verticillata			—							
Impatiens fulva	—				—					
Impatiens pallida						—				
Iris versicolor	—									
Itea Virginica										—
Jussiaea repens									—	
Kalmia glauca			—	—						
Larix Americana	—		—			—				
Lathyrus palustris		—								

Comparative Table of Species.	Crooked River.	Walloon River.	Sphagnum swamp N. Manitou.	Sphagnum swamp Mt. Katahdin.	Sphagnum swamp Long Island.	Arbor-vitæ swa'p N. Manitou.	Arbor-vitæ swa'p Roaring Brook.	Lake Calumet.	Horse-shoe Lake.	St. Francis River.
Ledum latifolium										
Leersia oryzoides										
Leitneria Floridana										
Lemna minor										
Lindera Benzoin										
Linnæa borealis										
Liquidambar styraciflua										
Lobelia cardinalis										
Lobelia syphilitica										
Lonicera glauca										
Ludwigia palustris										
Lycopodium lucidulum										
Lycopus Virginicus										
Lysimachia thyrsiflora										
Maianthemum Canadense										
Marchantia polymorpha										
Melilotus alba										
Mentha Canadensis										
Menyanthes trifoliata										
Mikania scandens										
Mimulus ringens										
Mitchella repens										
Mnium sylvaticum										
Morus rubra										
Myrica Gale										
Myrica cerifera										
Myriophyllum										
Naias flexilis										
Nelumbo lutea										
Nemopanthes fascicularis										
Nuphar advena										
Nymphæa odorata										
Nyssa sylvatica										
Nyssa uniflora										
Onoclea sensibilis										
Osmunda cinnamomea										
Osmunda regalis										
Peltandra undulata										
Penthorum sedoides										
Phragmites communis										
Picea nigra										
Pilea pumila										
Pinus resinosa										
Pinus Strobus										
Planera aquatica										
Plantago major										
Platanus occidentalis										
Polygonum densiflorum										
Polygonum amphibium										
Polygonum Hartwrightii										
Polygonum Muhlenbergii										
Polygonum scandens										
Polypodium incanum										
Populus balsamifera										
Populus monilifera										
Porella										
Potamogeton natans										

Comparative Table of Species.	Crooked River.	Walloon River.	Sphagnum swamp N. Manitou.	Sphagnum swamp Mt. Katahdin.	Sphagnum swamp Long Island.	Arbor-vitae sw'ap N. Manitou.	Arbor-vitae sw'ap Roaring Brook.	Lake Calumet.	Horse-shoe Lake.	St. Francis River.
Potentilla fruticosa	—									
Potentilla palustris			—							
Pontederia cordata			—					—		
Pyrus Americana			—	—						
Pyrus arbutifolia			—	—						
Quercus Michauxii										—
Rhexia Virginica					—					
Rhus Toxicodendron		—								—
Ricciocarpus natans								—		—
Rosa Carolina		—								—
Rubus triflorus		—								
Rubus hispidus					—					
Rumex verticillatus		—								
Sagittaria variabilis	—								—	
Salix amygdaloides	—								—	
Salix glaucophylla	—									
Salix longifolia									—	
Salix lucida		—								
Salix nigra									—	
Salix rostrata						—				
Sarracenia purpurea			—	—						
Sassafras officinale										—
Saururus cernuus										—
Scheuchzeria palustris				—						
Scirpus fluviatilis								—		
Scirpus lacustris	—							—	—	
Scirpus maritimus									—	
Scutellaria galericulata			—							
Scutellaria lateriflora						—				
Sicyos angulata									—	
Sium cicutaefolium									—	—
Smilacina trifolia				—						
Solanum Dulcamara		—								
Solidago patula		—								
Sphagnum squarrosum			—	—	—					
Spirodela polyrrhiza									—	—
Streptopus roseus							—			
Strophostyles palustris									—	
Symplocarpus foetidus						—				
Taxodium distichum										—
Taxus Canadensis						—	—			
Tecoma radicans									—	
Thalictrum purpurascens		—								
Thuidium delicatulum							—			
Thuya occidentalis	—		—	—	—	—	—			
Trientalis Americana		—					—			
Typha latifolia	—		—						—	—
Ulmus alata										—
Ulmus Americana		—								
Ulmus fulva									—	
Vaccinium Canadense			—	—	—					
Vaccinium macrocarpon			—							
Vaccinium Oxycoccus				—						
Vaccinium uliginosum				—						
Vaccinium Vitis-Idaea				—						

COMPARATIVE TABLE OF SPECIES.	Crooked River.	Walloon River.	Sphagnum swamp N. Manitou.	Sphagnum swamp Mt. Katahdin.	Sphagnum swamp Long Island.	Arbor-vitae swa'p N. Manitou.	Arbor-vitae swa'p Roaring Brook.	Lake Calumet.	Horse-shoe Lake.	St. Francis River.
Vallisneria spiralis	—									
Viburnum cassinoides				—						
Viola blanda		—				—				
Vitis cinerea									—	
Vitis riparia									—	
Wolffia Columbiana									—	
Zizaniopsis miliacea										—

EXPLANATION OF PLATES.

Plate 1. — Group of young tupelo, *Nyssa uniflora*, growing in the water and showing beginning of base enlargement. *Porella* growing on the trunks near water line. — Saint Francis River, Arkansas.

Plate 2. — Large tract of *Thuya occidentalis* killed by rise of water occasioned by construction of a dam. — Carp Lake, Michigan.

Plate 3. — 1, *Nuphar advena, Menyanthes trifoliata* and *Typha latifolia* in a small decadent lake, rapidly passing into a tamarack swamp. — North Manitou Island, Michigan. 2, Buck-bean zone, *Menyanthes trifoliata*, bordering small lake passing into tamarack swamp. — North Manitou Island, Michigan.

Plate 4. — 1, Border of tamarack swamp on North Manitou Island, *Phragmites communis, Typha latifolia* and *Menyanthes trifoliata* in the foreground, *Larix Americana* and *Picea nigra* in the background. 2, Tension line between land and water margins of small lake on North Manitou Island.

Plate 5. — Shrub and tree zones on margin of Sphagnum swamp; *Cassandra calyculata* in the foreground, *Larix Americana* and *Picea nigra* in the background.

Plate 6. — 1, A mountain peat bog surrounded by black spruce; other character plants are *Cassandra calyculata, Nemopanthes fascicularis, Kalmia glauca, Vaccinium Oxycoccus, V. uliginosum, V. Vitis-Idaea, Sphagnum* species, *Scheuchzeria palustris, Drosera rotundifolia* and *Sarracenia purpurea*. — Mount Katahdin, Maine. 2, Portion of same bog showing *Sphagnum, Drosera, Carex miliaris* and *Eriophorum gracile*.

Plate 7. — 1, Beginning of arbor-vitae swamp along outlet of lake on North Manitou Island. — 2, Interior of same swamp.

Plate 8. — 1, Lake margin zone of *Jussiaea repens* bordered with zone of *Scirpus maritimus*. — Horse Shoe Lake, Illinois. 2, Succession of

plant forms along the margin of an ox-bow lake; *Nelumbo lutea, Jussiaea repens, Scirpus maritimus, Salix nigra* and *S. amygdaloides*. — Horse-Shoe Lake.

Plate 9. — 1, Zone of *Scirpus maritimus* with *Polygonum Muhlenbergii* behind it, *Populus monilifera* and *Salix nigra* on the left, *Betula lutea* in the center, and *Salix amygdaloides* on the right. — Horse-Shoe Lake. 2, Margin of small stream which enters Horse-Shoe Lake. In the foreground is *Jussiaea repens*, in the middle ground, *Polygonum Muhlenbergii* and *Sium cicutaefolium*, and in the background a thicket of *Salix nigra, S. amygdaloides* and *S. longifolia* which merges into a dense thicket of *Forestiera acuminata*, the interior of which is shown in the next figure.

Plate 10. — 1, Thicket of *Forestiera acuminata* which spreads rapidly by vegetative propagation. Large tree in the foreground is *Salix nigra*. 2, *Forestiera acuminata*, showing common method of vegetative propagation. — Margin of Canteen Creek, near Horse-Shoe Lake.

Plate 11. — 1, Willow swamp along Canteen Creek, with *Forestiera acuminata, Cephalanthus occidentalis, Polygonum Muhlenbergii, Mentha piperita* and *Sagittaria variabilis*. 2, *Polygonum-Zizaniopsis* association in the St. Francis River, near Bertig, Arkansas.

Plate 12.— 1, Open water zone, Varner River, bordered by growth of *Nuphar advena* and *Azolla Caroliniana*. — Near Kennett, Missouri. 2. General view of cypress swamp in the Saint Francis River, near Kennett, Missouri.

Plate 13.— 1, Channel of Varner River bordered by growth of *Polygonum densiflorum*. 2, *Nuphar advena, Nymphaea odorata* and *Nelumbo lutea*, along the Varner River.

Plate 14.— 1, *Polygonum densiflorum, Typha latifolia, Saururus cernuus* and *Peltandra undulata*, cypress, button-bush and willow undergrowth.— Varner River, near Kennett, Missouri. 2, Mixed cypress and tupelo forest along the Saint Francis River: *Nuphar advena* and *Azolla Caroliniana* in the foreground.

Plate 15.— Group of young cypress trees, *Taxodium distichum*, growing in the water and showing enlarged base.

Plate 16.— 1, Medium sized cypress with group of "knees" projecting nearly four feet above the water which is 30 inches deep at this point. 2, Group of cypress trees in mesophytic condition; no knees or enlarged base.

Plate 17. — 1, Large cypress trees, 6 feet in diameter, surrounded by knees; the bases of these trees not enlarged. 2, Cypress with much enlarged base, surrounded by great number of knees, some of which are eight feet in height. — Margin of Saint Francis River, when usual waters have subsided.

Plate 18, — 1, Large cypress surrounded by knees. 2, Group of large tupelo, *Nyssa uniflora*, showing characteristic enlargement of base. The surrounding undergrowth consists of tupelo, button-bush, *Aralia spinosa* and *Mikania scandens*.

Plate 19. — 1, Tupelo showing enlarged base covered with *Polypodium incanum*. 2, Tupelo showing hollow base and general appearance at time of low water.

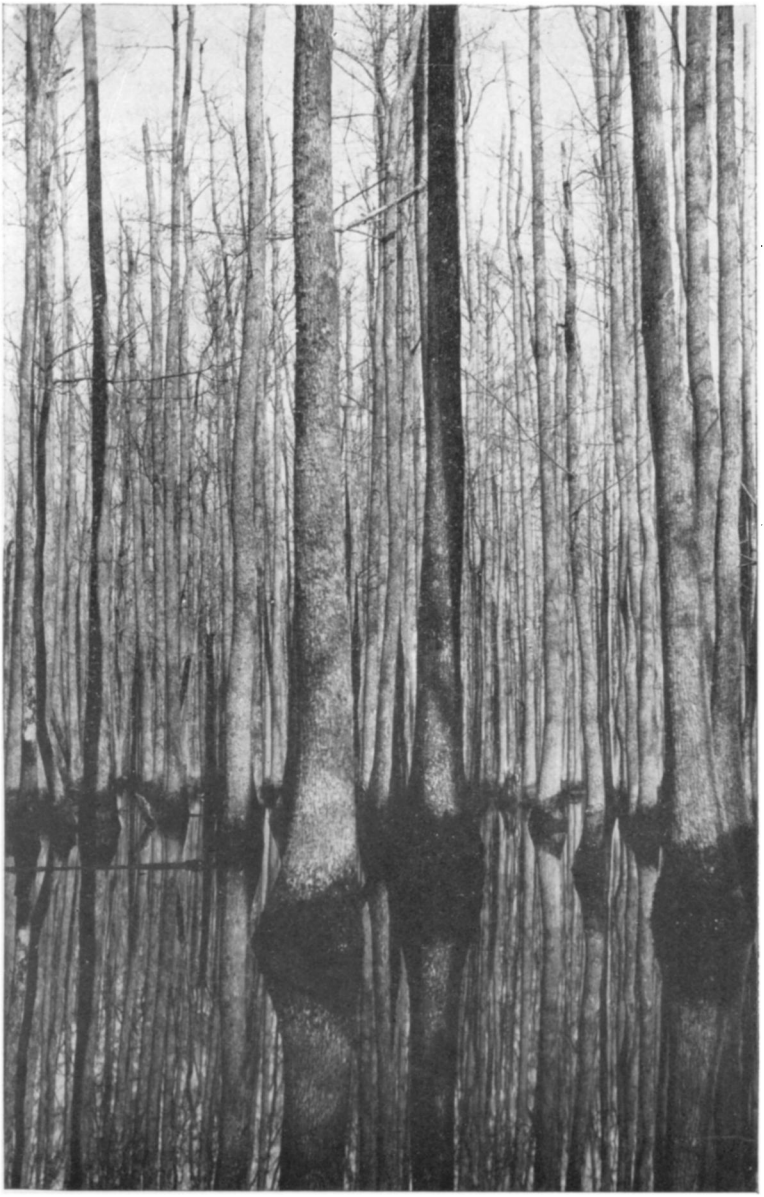
Plate 20. — 1, Along the Varner River: epiphytic vegetation consisting of grasses, sedges, *Rosa Carolina*, *Itea Virginica*, etc. 2, Marginal woods, along the Varner River: *Liquidambar styraciflua*, *Acer Drummondii*, *Sassafras officinale*, *Taxodium distichum*, *Cercis Canadensis*, *Lindera Benzoin*, *Ampelopsis quinquefolia*.

Plate 21. — Oleander, Cedar and Palmetto along margin of peat marsh, *Baccharis heterophylla*, dog-bush, in the foreground. — Bermuda Islands.

Plate 22. — 1, Cedar growing on margin of peat marsh, *Pteris* in the foreground. — Bermuda Islands. 2, Mangroves in Hungry Bay, Bermuda, showing branched prop-roots.

Plate 23. — *Rhizophora Mangle*, the mangrove, showing seeds developing on the tree and young seedlings in various stages of development.

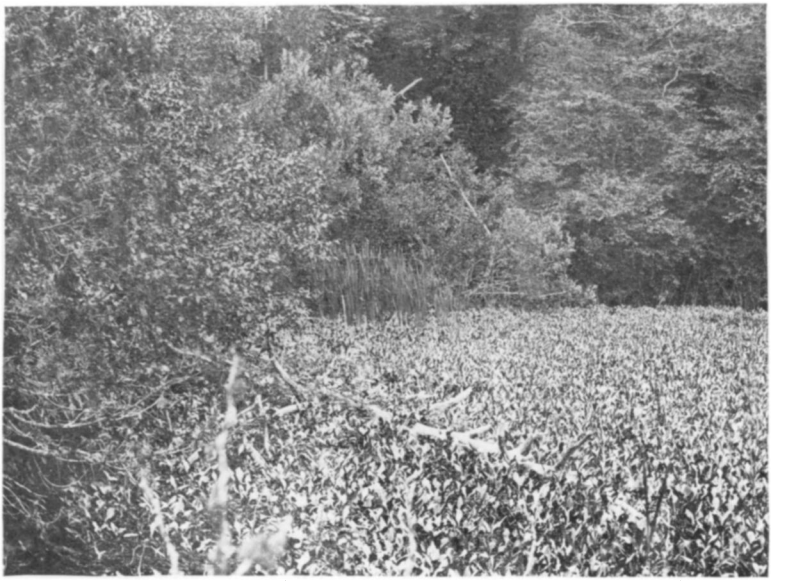
Plate 24. — 1, General view of the margin of a mangrove swamp, showing the prop and aerial roots. 2, *Avicennia nitida*, the false mangrove, showing root-like processes at the fork, and upward growing processes from the roots.



NYSSA UNIFLORA.

THUYA KILLED BY WATER.

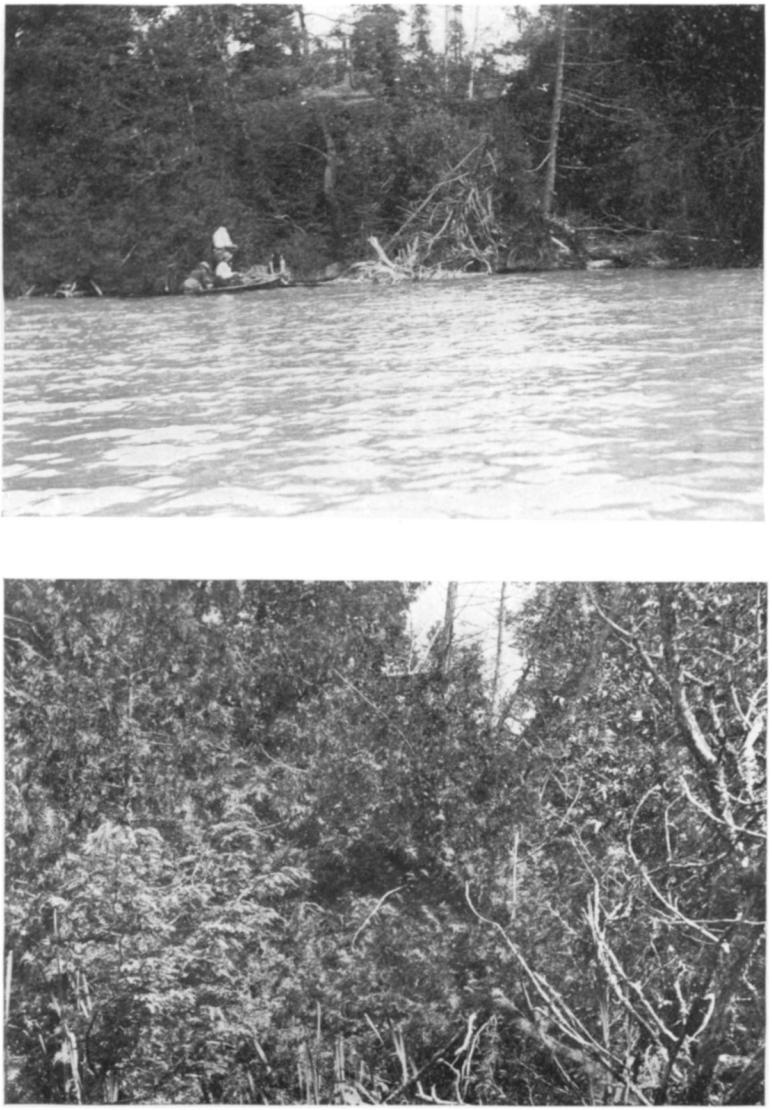
NORTH MANITOU ISLAND SWAMPS.



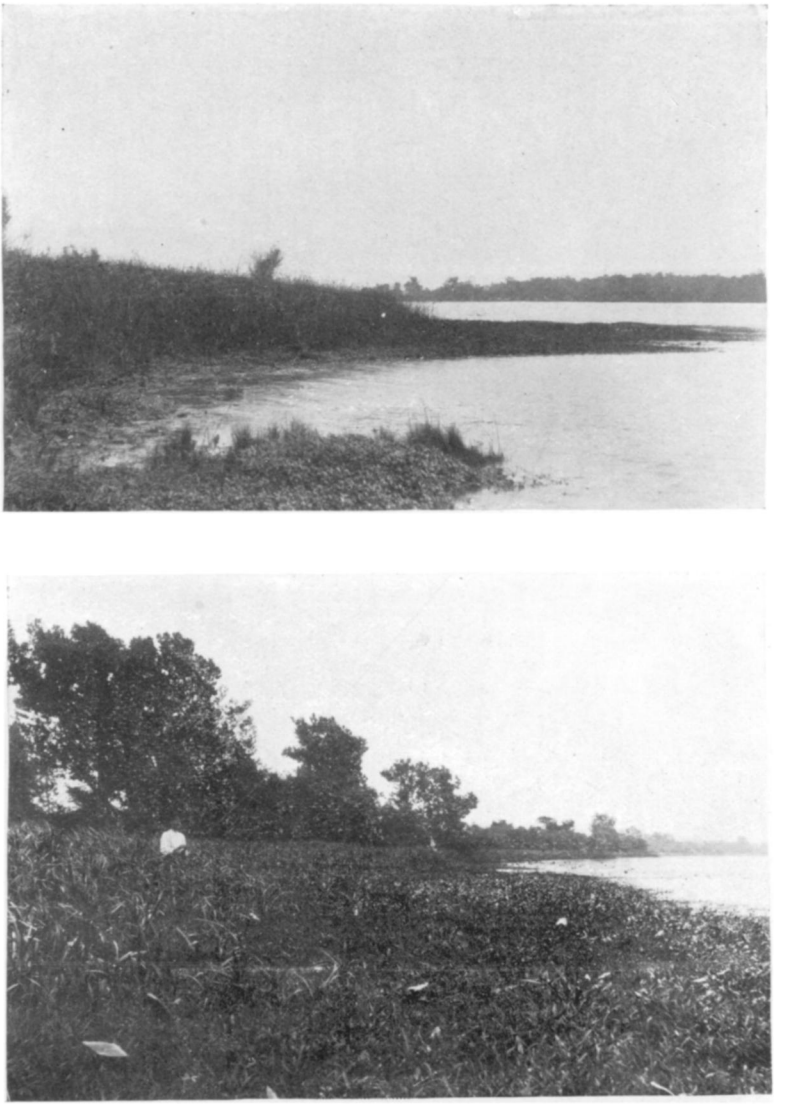
NORTH MANITOU ISLAND SWAMPS.

MARGIN OF SPHAGNUM SWAMP.

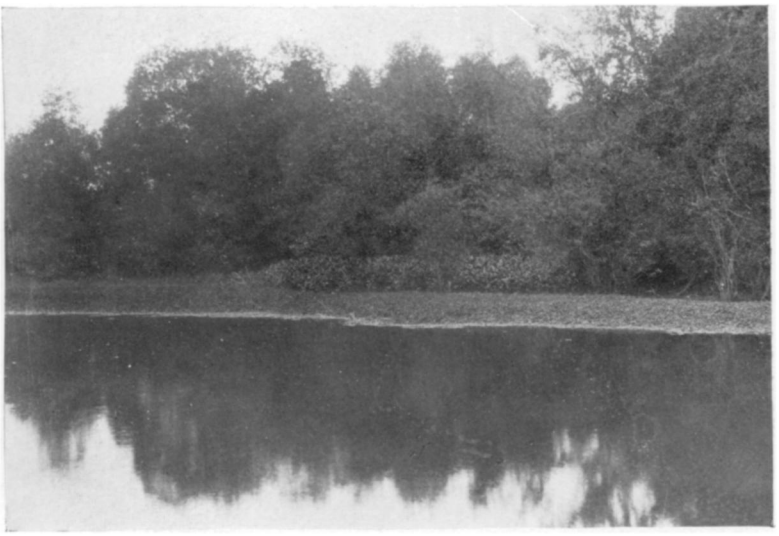
MOUNT KATAHDIN BOG.



ARBOR-VITÆ SWAMP.

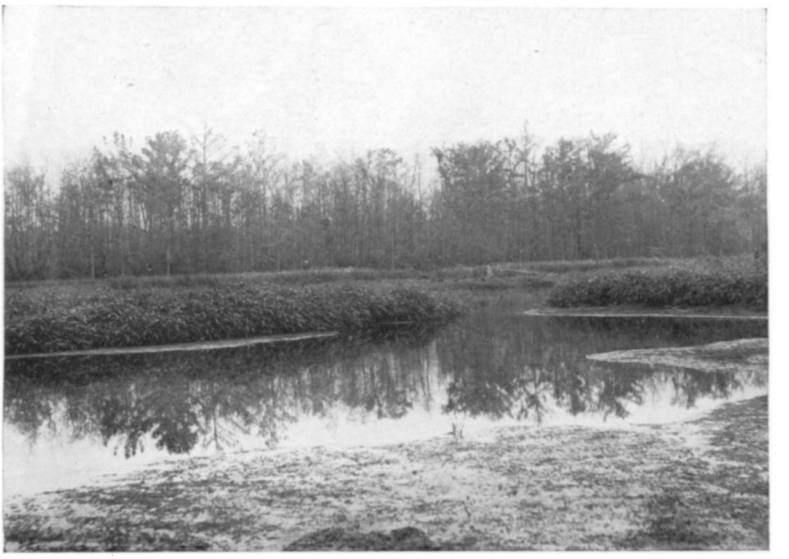


HORSESHOE LAKE SWAMP.



HORSESHOE LAKE SWAMP.

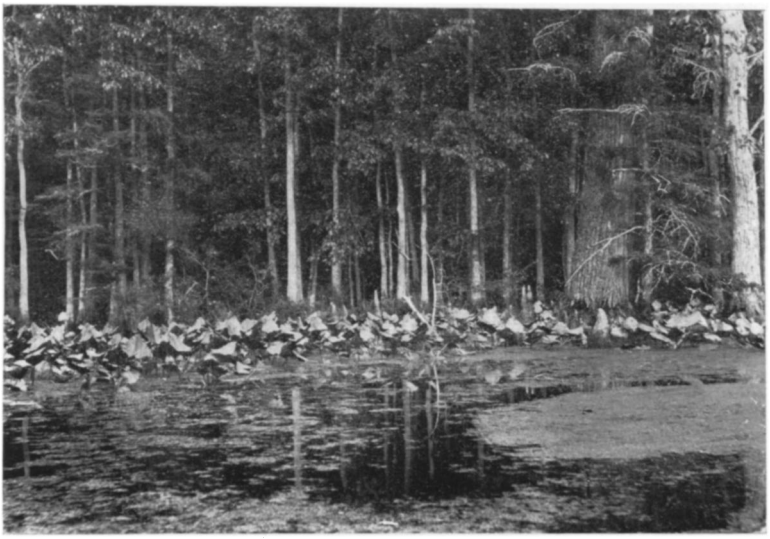
FORESTIERA ACUMINATA.



SOUTHERN SWAMPS.

CYPRESS SWAMPS.

SOUTHERN MISSOURI SWAMPS.



SOUTHERN MISSOURI SWAMPS.

TAXODIUM DISTICHUM.

TAXODIUM DISTICHUM.

TAXODIUM DISTICHUM.

TAXODIUM AND NYSSA.

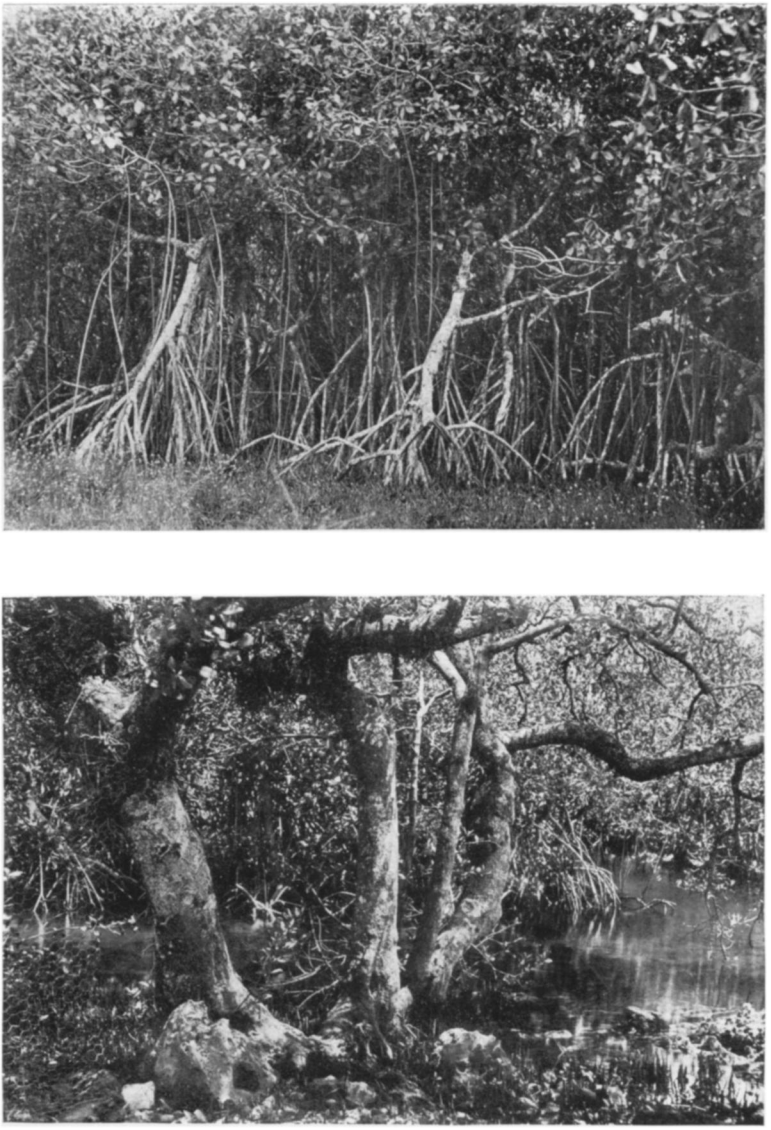
NYSSA UNIFLORA.

SOUTHERN SWAMP MARGINS.

BERMUDA MARSH.

BERMUDA MARSH.

RHIZOPHORA MANGLE.



MANGROVE SWAMP, BERMUDA.